AD-A156 688

20000811029

AIR COMMAND AND STAFF COLLEGE

Reproduced From Best Available Copy

DTIC FILE COPY

STUDENT REPORT

RETROFIT OF SAC KC-135C AND RC-135 AIRCRAFT [illegible]-56 ENGINES

MAJOR [illegible], JR. 85-2630

"insights into tomorrow"

DTIC ELECTE JUL 1 9 1985 S D

This document has been approved for public release and sale; its distribution is unlimited.

85 7 08 068

DISCLAIMER

The views and conclusions expressed in this document are those of the author. They are not intended and should not be thought to represent official ideas, attitudes, or policies of any agency of the United States Government. The author has not had special access to official information or ideas and has employed only open-source material available to any writer on this subject.

This document is the property of the United States Government. It is available for distribution to the general public. A loan copy of the document may be obtained from the Air University Interlibrary Loan Service (AUL/LDEX, Maxwell AFB, Alabama, 36112) or the Defense Technical Information Center. Request must include the author's name and complete title of the study.

This document may be reproduced for use in other research reports or educational pursuits contingent upon the following stipulations:

-- Reproduction rights do not extend to any copyrighted material that may be contained in the research report.

-- All reproduced copies must contain the following credit line: "Reprinted by permission of the Air Command and Staff College."

-- All reproduced copies must contain the name(s) of the report's author(s).

-- If format modification is necessary to better serve the user's needs, adjustments may be made to this report--this authorization does not extend to copyrighted information or material. The following statement must accompany the modified document: "Adapted from Air Command and Staff Research Report ___(number)___ entitled ___(title)___ by ___(author)___."

-- This notice must be included with any reproduced or adapted portions of this document.

REPORT NUMBER 85-2630

TITLE RETROFIT OF SAC EC-135C AND RC-135 AIRCRAFT WITH CFM-56 ENGINES

AUTHOR(S) MAJOR WILLARD N. STOOKE, JR., USAF

FACULTY ADVISOR MAJOR JEFFREY J. POLLES, ACSC/EDOWD

SPONSOR LT COL ROY B. PHILLIPS, HQ SAC/XPFC

Submitted to the faculty in partial fulfillment of requirements for graduation.

AIR COMMAND AND STAFF COLLEGE
AIR UNIVERSITY
MAXWELL AFB, AL 36112

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED

1b. RESTRICTIVE MARKINGS:

2a. SECURITY CLASSIFICATION AUTHORITY:

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE:

3. DISTRIBUTION/AVAILABILITY OF REPORT:

4. PERFORMING ORGANIZATION REPORT NUMBER(S): 85-2630

5. MONITORING ORGANIZATION REPORT NUMBER(S):

6a. NAME OF PERFORMING ORGANIZATION: ACSC/EDCC

6b. OFFICE SYMBOL *(If applicable)*:

7a. NAME OF MONITORING ORGANIZATION:

6c. ADDRESS *(City, State and ZIP Code)*: Maxwell AFB AL 36112

7b. ADDRESS *(City, State and ZIP Code)*:

8a. NAME OF FUNDING/SPONSORING ORGANIZATION:

8b. OFFICE SYMBOL *(If applicable)*:

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

8c. ADDRESS *(City, State and ZIP Code)*:

10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.

11. TITLE *(Include Security Classification)*: RETROFIT OF SAC EC-135C AND

12. PERSONAL AUTHOR(S): Stooke, Willard N., Jr., Major, USAF

13a. TYPE OF REPORT:

13b. TIME COVERED: FROM ______ TO ______

14. DATE OF REPORT *(Yr., Mo., Day)*: 1985 April

15. PAGE COUNT: 43

16. SUPPLEMENTARY NOTATION:

ITEM 11: RC-135 AIRCRAFT WITH CFM-56 ENGINES (U)

17. COSATI CODES

FIELD	GROUP	SUB. GR.

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*:

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

This report is an analysis of the advantages and disadvantages of retrofitting SAC's EC-135C and RC-135 fleet with the CFM-56 engine "package" being used to convert the KC-135As to KC-135Rs. It reviews selected components of the modification package and compares the performance capabilities of current and modified aircraft during takeoff, cruise, receiver aerial refueling, and landing. The projected fuel savings on the investment dollar are calculated against the criteria of a 25 year life cycle as stipulated in AF Regulation 173-13, USAF Cost and Planning Factors, and could pay for the retrofit of the 31 aircraft in 18 years. Finally, the advantage of logistics commonality among all three aircraft is assessed.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐

21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL: ACSC/EDCC Maxwell AFB AL 36112

22b. TELEPHONE NUMBER *(Include Area Code)*: (205) 293-2483

22c. OFFICE SYMBOL:

PREFACE

This report analyzes the advantages and disadvantages of retrofitting SAC's EC-135Cs and RC-135s with the CFM-56 package of components that is being used on the KC-135A aircraft to create the KC-135R. It provides a framework for assessing the relative improvements to the aircraft while identifying certain aspects of the program that warrant additional study. The report is written in layman's terms with the intent of providing or identifying the information that should be considered when the final decision concerning the retrofit proposal is made.

A special word of thanks goes to several people for their assistance in preparing this project. Major George H. Kotti provided extensive information on the KC-135R, including data that was vital to constructing the performance tables. Lt Col John R. Grellman and Lt Col David A. Heideman volunteered their time to edit the draft. Lt Col Roy B. Phillips, the project sponsor, and Major Jeffrey J. Polles, the project advisor, provided editing and other guidance. Michaele A. Stooke edited and typed the final report.

DTIC COPY INSPECTED 1

Accession For
NTIS GRA&I
DTIC TAB
Unannounced
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A-1

ABOUT THE AUTHOR

Major Willard N. Stooke, Jr. began his military career at the United States Air Force Academy where he graduated in 1971. After pilot training at Williams AFB, Arizona, and Castle AFB, California, he flew KC-135As at Grand Forks AFB, North Dakota, where he accrued over 2,000 hours of flying time. His operational experience there included TDYs to several overseas locations and most CONUS SAC bases. A rated supplement tour as an intelligence officer in 1979 exposed him to tactical operations and non-rated duties. While at Shaw AFB, South Carolina, on this tour he became involved with the intelligence planning and support of the then Rapid Deployment Force. Returning to the cockpit in 1982, he flew over 1,000 hours in the EC-135Cs (SAC's Airborne Command Post) at Offutt AFB, Nebraska. It was on one of those missions while reading about the KC-135R that he first became interested in the feasibility of applying the CFM-56 retrofit package to the EC-135Cs and the RC-135s. Major Stooke is currently a student in the class of 1985 at Air Command and Staff College, Maxwell AFB, Alabama. In addition, he has completed the National Security Management Course and has a Master of Arts Degree in Public Administration from the University of North Dakota.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

TABLES

EXECUTIVE SUMMARY

Part of our College mission is distribution of the students' problem solving products to DoD sponsors and other interested agencies to enhance insight into contemporary, defense related issues. While the College has accepted this product as meeting academic requirements for graduation, the views and opinions expressed or implied are solely those of the author and should not be construed as carrying official sanction.

"insights into tomorrow"

REPORT NUMBER 85-2630

AUTHOR(S) MAJOR WILLARD N. STOOKE, JR., USAF

TITLE RETROFIT OF SAC EC-135C AND RC-135 AIRCRAFT WITH CFM-56 ENGINES

I. Purpose: To identify the advantages and disadvantages of retrofitting SAC EC-135C and RC-135 aircraft with CFM-56 engines as an interim measure until a follow-on airframe is produced.

II. Problem: To determine what modifications could be made to the EC-135C and RC-135 aircraft to enhance their mission capabilities. This study provides a framework for analyzing enhancement alternatives and reviews the systems of the CFM-56 engine package within this framework.

III. Discussion of Analysis: The analysis is presented as a relative comparison of the aircraft modified with the CFM-56 engine package versus the aircraft in their current configuration. Calculations were made using the actual data base from FY 84 and worst case conditions. Three assumptions were made in the study. (1) The number of aircraft, aircrews, and support personnel after the modification would remain unchanged. (2) The average inflation figure projected for 1988 to 1992 was applied as a constant factor beyond 1992. (3) Calculations were based upon conversion of the EC-135Cs and RC-135s by the start of FY 85. These assumptions were made at the expense of absolute accuracy, but they do provide a means of assessing the relative performance of each aircraft.

IV. Data: SAC KC-135As are currently being modified with CFM-56 engines and a package of over 30 other components. This report

CONTINUED

assesses the changes that would occur if the EC-135Cs and the RC-135s were retrofit with the same package. Selected components of the package are reviewed in light of special limitations or mission requirements of the ECs and RCs. Some of these components could require major modifications and warrant further study to determine technical feasibility and additional R&D costs. Aircraft takeoff performance would be improved, and maximum refueling, best range, and maximum endurance altitudes would be increased as a result of the new engines. A penalty would occur to the options during a landing diversion as a result of the increased empty operating weight of the aircraft that would reduce the fuel available at the normal maximum landing gross weight. An important feature of this proposal is that the potential fuel savings of the engines could pay for the modification. If all 31 EC-135C and RC-135 aircraft were converted, system payback could occur after approximately 18 years. Other possible cost savings could result from "piggybacking" upon the existing Class V modification to the KC-135As; creating a logistical economy through a greater commonality of parts among the ECs, KCs, and RCs; salvaging the TF33-P-9 engines or components; and converting the EC-135Cs and RC-135s to tankers when they are replaced by a follow-on aircraft.

V. <u>Conclusions:</u> The primary benefits of the CFM-56 retrofit would affect performance, cost, and logistical support, a broad range of factors associated with weapon system operations. The primary disadvantages are the reduced landing diversion options and additional R&D costs associated with specific component modifications.

VI. <u>Recommendations:</u> Before a program to retrofit the EC-135Cs and RC-135s is initiated, several additional studies should be conducted to determine equipment compatibility, modifications that would be necessary, and the R&D or additional costs that would be incurred by the modifications. The system net cost increase or decrease based upon the findings of these studies could significantly change the payback period of the modification. If the payback period for the 31 aircraft remains less than 25 years (as stipulated in AF Regulation 173-13, <u>US Air Force Cost and Planning Factors</u>) the increased performance, logistical commonality with the KC-135R, and potential for continued use as a tanker after a follow-on airframe is procured are factors that put this program in strong contention for implementation.

Chapter One

INTRODUCTION

For over two decades the EC-135C aircraft that fly as SAC's Airborne Command Post (ABNCP) or "Looking Glass" and the RC-135 aircraft variants that carry out global reconnaissance have proven to be reliable airplanes, well suited for the demands of these missions. The functions, taskings, and capabilities of the airplanes and their associated missions have been expanded and upgraded throughout the history of their existence. Due to this continuing expansion and anticipated changes in the future concepts of operation, in the "Joint CINC Justification for Major System New Start for WWABNCP [World Wide Airborne Command Post] Replacement Aircraft" planners have identified the requirement for a short takeoff and landing (STOL) transport type aircraft to replace the EC fleet. (22:--) Interim proposals to bridge the gap between present capabilities and those of the future airframe are also being considered. This study proposes one possible interim solution for both the EC and RC fleets that would improve performance, accommodate limited subsystem additions, and provide a high degree of engine commonality with the growing KC-135R fleet through a retrofit of the current airframe with CFM-56 engines. The solution is analyzed against operations as they currently exist and can be used as the framework for comparing other interim alternatives.

RESEARCH HYPOTHESIS

This study is an analysis of some of the factors to be considered in determining any benefits of retrofitting SAC EC-135C and RC-135 aircraft with CFM-56 engines. The CFM56-2B-1 (hereafter referred to as CFM-56) engines are produced by a consortium of General Electric (GE) in the United States and Société Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA) of France on a 50/50 share basis under the name of CFM International. (2:778) The SAC KC-135A fleet is currently being retrofit with these engines as part of a modification package costing $16 million per aircraft. The purpose of this study is to identify the advantages and disadvantages in performance, efficiency, and operational flexibility of re-engining the EC-135Cs and RC-135s. The program is assessed against the 25 year life cycle costing model stipulated for cargo aircraft in AF Regulation 173-13, US Air Force Cost and Planning Factors.

BACKGROUND INFORMATION

For those not familiar with SAC reconnaissance and command and control operations, this section is a brief description of SAC's EC-135C and RC-135 aircraft and their missions. Information on the KC-135R retrofit package is also provided.

The EC-135C aircraft are configured to fly SAC's Airborne Command Post or "Looking Glass" missions and are powered by four TF33-P-9 engines that produce 16,000 pounds of thrust each. There is a fleet of ten aircraft normally operating out of Offutt AFB, Nebraska, cycling through 3 daily shifts of 8 hours and 20 minutes each to fulfill the requirements of maintaining a continuous ABNCP, the heart of the Post Attack Command and Control System (PACCS). The PACCS link is a critical element in SAC's nuclear command, control, and communications network. Two aircraft are also located at Ellsworth AFB, South Dakota. They alternate flights between periodic ABNCP missions, other PACCS positions, and higher headquarters tasking. While there are other EC-135 variants (12:21), this study will only consider the EC-135C for re-engining due to the equipment load and the greater amount of fuel burned in support of the ABNCP mission.

The RC-135s considered in this study encompass all RC-135 variants (S, U, V, and W) used by SAC. Sixteen of the aircraft are assigned to Offutt AFB and fly some operational missions from that location. Most of the operational missions are flown from four Forward Operating Locations (FOLs) throughout the world. These missions usually last from 10 to 18 hours, requiring aerial refuelings. The aircraft collect signals intelligence (SIGINT) and are the backbone of the I (intelligence) in SAC's C^3I equation. In addition, three other aircraft operate exclusively out of Eielson AFB, Alaska. All of these aircraft are loaded with a myriad of sophisticated electronic collection equipment that has significantly increased their empty operating weight (which ranges from 145,000 pounds to 165,000 pounds depending upon the model). Since they all face this increasing weight problem, the term RC-135 will be used to refer to all 19 aircraft in SAC's fleet. In the performance computations the heaviest empty operating weight will generally be used to show the worst case situation. Due to their similar empty operating weights, the lighter RC-135s approximate the performance of the EC-135Cs.

The SAC fleet of KC-135A Stratotankers is currently undergoing a Class V modification that is programmed to retrofit the aircraft with CFM-56 engines and other upgraded subsystems. While the engines will increase the thrust from approximately 12,000 pounds each to 2[illegible],000 pounds each and are therefore the most significant single improvement of this package, over 30 other subcomponents are also modified for a total cost of $16 million per aircraft. The goal of the program is to reduce the current and future tanker shortfall by increasing the fleet offload

capability by 50 percent at a fraction of the expense of developing a new airplane. The result of this program is a Stratotanker redesignated the KC-135R. Aircraft number two was delivered to the SAC Commander in Chief during formal acceptance ceremonies on 2 July 1984. SAC will transition to the new aircraft with a production schedule that calls for a delivery rate that will increase to six airplanes per month in late 1986. The final airplane should be completed in 1993 and conclude a modification program that will extend the service life of the airframe well beyond the year 2010. (3:4,5; 16:1)

RESEARCH OBJECTIVES

The advantages or disadvantages of retrofitting SAC EC-135C and RC-135 aircraft with CFM-56 engines will be analyzed through the review of five research objectives.

1. Review the significant components of the KC-135R retrofit package that would be appropriate on the EC/RC aircraft.

2. Review the potential for future additional equipment or fuel load increases that would result from the greater thrust of the CFM-56 engines.

3. Determine the performance characteristics of the aircraft with the new engines in the takeoff, cruise, and receiver aerial refueling phases of flight in comparison with current configurations.

4. Project the dollar savings that could result from such a retrofit based upon decreased fuel consumption and reduced tanker refuelings.

5. Identify other aspects of operations that may result in greater flexibility, consolidation, or efficiency if such a program is implemented.

METHODOLOGY

Every effort was made to use actual data and independent analysis as the basis for this study. While a CFM International report formulated generalized scenarios in support of various portions of the analysis, this study used the actual fiscal year 1984 data base and applied the performance computations from the C-135B (for the RC-135W), EC-135C, and KC-135R tech order performance manuals. The basic data and the calculations used to determine any performance or savings factors are fully explained so that the process can be updated or modified as necessary.

The factors applied in the study were selected based upon a conservative approach. Factor averages were used or, as in the

case of takeoff data and the RC-135 basic operating weight, worst case conditions were selected. The performance of modified EC-135C and RC-135 aircraft as determined from the KC-135R performance manual was adjusted for the increased operating weights of the EC and RC airframes, and was degraded using the factors for the increased antenna drag that are currently applied.

ASSUMPTIONS AND LIMITATIONS

Several assumptions were made to simplify the analysis of this proposal. The number of aircraft, aircrews, support personnel, and per flying hour non-fuel dollars necessary to carry out the mission after retrofit of the CFM-56 modification package was assumed to remain unchanged. Second, the fuel savings were multiplied by inflation factors in table 5-1 of AF Regulation 173-13, US Air Force Cost and Planning Factors, to project the annual and cumulative system savings. Since the table does not provide factors beyond 1992, the average inflation factor used in the table between the years 1988 and 1992 was applied as a constant factor after 1992. In the last assumption, calculations using the CFM-56 package were based upon the entire fleet being converted by the start of FY 85. In reality, however, money would not be available until the 1988 Program Objective Memorandum (POM) cycle and the 31 aircraft would require several years to modify. (22:--) While these simplifications are possibly made at the expense of absolute accuracy, they do provide a means of assessing the relative performance of each aircraft.

Certain aspects of this study were not fully developed due to limits on the resources available to conduct the analysis. In particular, the review of the direct applicability of the components of the CFM-56 package was limited to only a few of the major systems. Most subsystems would likely be incorporated, but each one should be analyzed for possible deletion or modification. In the RC-135 fuel savings computations, there is a possible inaccuracy in the number of support tanker hours saved per refueled operational mission. This information is not tracked under present accounting systems and was estimated as explained in chapter 4. The final limitation affected the time and distance computations. The difference in the hours or gallons of fuel that would be held in reserve by current and modified aircraft could not be accurately determined. Instead, computations were made by burning all fuel at altitude until tanks were empty. Despite these limitations, most of the data base was current and accurate and provided a valid means of comparison.

Chapter Two

ACTUAL AND POTENTIAL EQUIPMENT UPGRADES

A CFM-56 engine retrofit of the EC-135C and RC-135 fleets will make two categories of upgrades possible—improvements to the basic airframe and the potential to accommodate future mission specific equipment. The improvements to the basic airframe include the higher thrust engines and a "package" of over 30 other upgraded systems that are designed to increase the performance and reliability of the aircraft. The potential for additional equipment is limited as will be explained later in this chapter.

BASIC AIRFRAME UPGRADE

Most of the major system upgrades that are currently being retrofit on the KC-135As are suggested for retrofit on the EC-135Cs and RC-135s. Systems most critical to aircraft control and performance have been hardened against electromagnetic pulse (EMP)* to increase the survivability of the aircraft in a nuclear environment. The systems explained below were selected as those most significant to the performance of the aircraft. A complete list of system changes in the KC-135R package is included in appendix 2.

CFM-56 Engines

The focal point of the retrofit program is the new CFM-56 turbofan engine developed and produced by CFM International. The engine has a high bypass ratio of 6.05:1 with a thrust rating of 22,000 pounds. (18:21,25) Compared to the current TF33-P-9 engines, the CFM-56 produces an additional 6,000 pounds of thrust per engine with an approximate fuel savings of 20 percent. (5:51) Engine performance and reliability have been proven commercially with almost two million flight hours on the re-engined DC-8-70 series aircraft and militarily with several thousand flight hours on the KC-135R. (16:3)

---

*The list of components that are EMP hardened is classified and is maintained by the KC-135R Acquisition Manager in the Directorate of Aeronautical Requirements, Headquarters SAC.

Two features of the CFM-56 engine should be noted in particular. First, the CFM-56 has a Power Management Control (PMC) unit that allows the pilot to preset a takeoff or climb thrust on the gages and then follow that with a single throttle adjustment that will automatically compensate for changes and maintain the proper thrust setting. (16:3) Second, a Turbine Engine Monitoring System (TEMS) is installed on each engine to automatically record critical performance parameters in support of the SAC Engine Condition Monitoring Program. (18:93-95) These features make the CFM-56 engines easier to operate and maintain.

Other Systems

Four of the systems or subsystem groups being upgraded on the KC-135R are specifically explained here because of their significant impact upon aircraft control, performance, or operational capabilities.

Integrated Drive Generators. The Integrated Drive Generator (IDG) system will improve electrical power source reliability. While the present generators have to be manually engaged and parallelled, the IDGs can be set to come on line automatically once the engines are started and will thus shorten quick-response timing. To reduce maintenance delays caused by generator malfunctions, a built-in test capability will assist diagnosis of problems. (3:5) There are, however, two constraints with the IDG system since the 40 KVA generators on the KC-135R would have to be replaced by the 120 KVA generators presently used on the ECs and RCs. First, the larger generators may not fit without major modification to the engines or the cowlings. Second, the larger generators may provide too much power for the IDG system to handle and force the use of the current constant speed drive system. These factors must be further analyzed to determine overall system compatibility and any additional research and development (R&D) costs that would be added to the system total cost. (22:--)

Landing Gear and Related Components. Another modification is a new landing gear system and the related components of the Mark III anti-skid brakes and a rudder-pedal nosewheel steering system. The new landing gear allows the maximum takeoff gross weight to increase from 300,000 pounds to 320,000 pounds, however, there would be no change in the current EC and RC normal landing maximum gross weight (200,000 pounds). The impact of this limitation is explained in chapter 3. The proposed five-rotor Mark III brakes provide some improvement to the stopping distance on wet or icy runways over the five-rotor Mark II brakes currently used on the ECs and RCs. (18:28) Since the improvement is minimal, additional study of both brake systems should be conducted to determine any trade-offs between the cost savings of retaining the current system versus future maintenance and logistical advantages that would result from a standard brake system used fleet wide. The rudder-pedal nosewheel steering system results in smoother

aircraft response to pilot control at slower taxi speeds. It is also more conducive to coordinated takeoff control inputs since the rudder and the nosewheel are both controlled by the rudder pedals, (4:42) thus freeing the pilot's left hand to hold the yoke.

Engine Failure Assist System. The Engine Failure Assist System (EFAS) is designed to overcome the initial directional control problems of asymmetrical thrust associated with an outboard engine failure during takeoff or go-around. When such a failure occurs, a fan differential sensor begins to make rudder inputs when the difference between the speeds of the outboard engines exceeds 500 RPM. The amount of automatic rudder input is proportional to the aircraft speed up to 200 KEAS, when the system disengages. With the EFAS, ground minimum control speed is reduced by 15-20 knots. (3:5; 18:138) This system significantly reduces the risk involved during two of the most critical phases of flight.

Auxiliary Power Unit. The final modification considered is the dual Auxiliary Power Unit (APU) system that provides electrical power and sufficient bleed air to start the engines or run the Environmental Control System (ECS) on the KC-135R. (3:6) Such a system is required on the EC-135C and RC-135 aircraft, but it must meet two specifications before it can be installed. Due to the design of the CFM-56 engine, a cartridge start is not possible and dual APUs are essential to start two engines simultaneously to meet the alert start timing requirements under Emergency War Order (EWO) conditions. Although the KC-135R has sufficient room in the cargo compartment to accommodate two APUs, the ECs and RCs do not. As a result, additional R&D funds may be required to develop new compact APUs to fit on the aircraft. Not only must the APUs provide a primary and backup engine start capability, they must also have sufficient electrical output to operate the additional banks of electronic equipment in the ECs and RCs while on the ground, and sufficient bleed air to run the ECS to cool that equipment. Without a dual APU system that meets these two criteria, the CFM-56 re-engining program cannot be implemented. (22:--)

MISSION SPECIFIC EQUIPMENT UPGRADE POTENTIAL

The second category of upgrade is the potential for expansion of the equipment used to carry out the airborne operational missions. This will occur as a result of increasing the maximum allowable takeoff gross weight from 300,000 pounds to 320,000 pounds. Some of this increase will be offset by the 11,000 pound weight of the modification package,* with a remaining expansion capability of 9,000 pounds, either as fuel or equipment. The equipment expansion

---

*The weight of the conversion package adds 13,000 pounds to the empty operating weight of the KC-135A, replacing J57-P-59W

potential is tempered, however, by the fact that both aircraft either will be or are "cubed out."

There are several equipment additions that have been funded to modify the EC-135C fleet. These major systems include equipment to link with the Ground Wave Emergency Network (GWEN), the Military Strategic and Tactical Relay System (MILSTAR), and the Nuclear Detection System (NDS) designed to enhance communications and operations in a nuclear environment. Equipment and work stations will also be added under the "Pacer Link" program that will be a retrofit of a universal battlestaff and communications suite that will add new radios to standardize the connectivity of the WWABNCP fleet. When these modifications are complete, room for equipment expansion will be limited to the space on existing racks. (22:--)

The RCs are currently "cubed out" and have no interior space left for major equipment expansion. They will not be able to make use of any internal equipment upgrade potential unless current systems are replaced. Therefore, they would only be able to capitalize upon increased performance by carrying additional fuel.

SUMMARY

Some of the components of the CFM-56 retrofit package on the KC-135A would have to be modified to make them compatible with the specifications of the EC-135Cs and RC-135s. A major limitation is the large amount of electrical power required to operate the equipment on the airplanes. This requirement may overtax the capabilities of the current modification package on the ground with the dual APU system and in the air with the IDG system. Additional research to determine the technological feasibility and R&D costs for required modifications will be necessary before a final acquisition decision is made. Research should also be conducted into the possibility of increasing the normal landing maximum gross weight to at least offset the increased empty operating weight of the aircraft resulting from the modification package. The potential for operational equipment expansion is minimal due to space limitations from current or soon to be added components. Heavier major components could be added, but only if they were traded for existing units.

---

engines that weigh 4,770 pounds each. Since the TF33-P-9 engines weigh 5,285 pounds each (500 pounds heavier), the total package weight differential would be reduced by 2,000 pounds (500 pounds x 4) for a net change to the EC/RC empty operating weight of 11,000 pounds. (23:--)

Chapter Three

PERFORMANCE COMPARISONS

The components of the CFM-56 engine modification package discussed in chapter 2 will result in several performance changes. Takeoff performance will be improved by the increased thrust; missions can be flown at higher cruise and loiter altitudes; and there will be a lower fuel consumption rate due to the high bypass technology of the engine. Landing fuel reserves would be adversely affected, though, due to the increased empty operating weight of the aircraft. Each of these anticipated changes will be discussed in this chapter as they affect specific phases of flight.

TAKEOFF PERFORMANCE

A variety of takeoff performance data and profiles must be computed to begin to understand the full advantage of the proposed engine modification. The comparisons that follow are based upon operations from Offutt AFB since its use is common to both the ECs and the RCs, and its runway is the one most often used. The performance gains are also representative of the improvements that would be seen at the RC-135 FOLs. The parameters of the runway environment include (1) 10,500' of runway available that for the purpose of this presentation will be considered to have no grade and no obstacle, and (2) weather conditions of 90°F and 1,000' pressure altitude. The weather conditions approximate the average maximum heating during July as taken from Base Weather Climatology, and result in the worst case performance situation. (10:14) The comparisons will be made using a basic operating weight with the current configuration of 145,000 pounds for the EC-135C and 165,000 pounds for the RC-135. (This basic operating weight applies only to the heaviest RC variants, but has been selected as the worst case example.) The increased basic operating weights after the 11,000 pound modification will be 156,000 pounds for the EC-135C and 176,000 pounds for the RC-135. Performance figures after the modification were calculated using the KC-135R Flight Manual Performance Data and applying the performance degrade factors for the other aircraft that result from the increased drag caused by external antennas.

The first comparison of the takeoff performance (table 3-1) is made with all aircraft using a common takeoff gross weight of

270,000 pounds. From this comparison two conclusions can be drawn. First, at the same takeoff gross weight, the modified aircraft have a critical field length over 1,000 feet shorter than that of the current configuration. If the lengths of the missions are not increased, the modified aircraft could be flown at the same takeoff gross weight and use the shorter critical field lengths as increased margins of performance safety. Second, there is a slight flight time performance penalty, but it is actually due to 11,000 pounds less fuel as a result of the offsetting weight of the modification package. This is significant in that it indicates the potential for saving 11,000 pounds of fuel per mission under such parameters.

Table 3-1. Takeoff Comparison With a 270,000 Pound Gross Weight

Aircraft	Critical Field Length	Best Range Mileage	Maximum Endurance Time
EC-135 (Current)	9,800'	5,440 NAM*	12.8 hrs.
EC-135C (Modified)	8,600'	5,511 NAM	12.6 hrs.
RC-135 (Current)	9,800'	4,094 NAM	9.7 hrs.
RC-135 (Modified)	8,600'	3,998 NAM	9.4 hrs.

NOTES: *Nautical Air Miles
Computed for 90°F, 1,000' P.A., 30° flaps, and no grade.
Climb and cruise data computed for standard day + 15°C.
Performance degrade factors. EC: climb-10%, range and endurance-7%, RC: climb-16%, range-13%, endurance-11%.
Climb mileage and time added to range and endurance.
Fuel burned at altitude until tanks are empty.

SOURCES: C-135B Flight Manual, Appendix I, Performance Data, Published under authority of the Secretary of the Air Force, June 1966, pp. 1A5-12 and 1A6-9; EC-135C Flight Manual, Appendix I, Performance Data, Published under authority of the Secretary of the Air Force, February 1966, pp. 1A2-4,1A3-48B,1A4-9,1A5-10, and 1A6-5; KC-135R Flight Manual, Appendix I, Performance Data, Published under authority of the Secretary of the Air Force, March 1984, pp. 1A2-5,1A2-9,1A3-42,1A3-43,1A5-17,1A5-18, and 1A6-8; and "Performance Data Corrections" used by RC-135 aircrews.

Since the increased thrust improves takeoff performance, a second comparison can be made using takeoff fuel loads increased to extend the number of unrefueled hours on each sortie. In table 3-2, 25,000 pounds of fuel have been added to the modified aircraft so that the critical field length equals that of the current aircraft. Climatological conditions remain the same as in table 3-1. This comparison illustrates that operating with an identical critical field length, the CFM-56 engines are able to carry more and extend the endurance flight time by almost two hours on the EC-135C, and well over an hour on the RC-135. The full impact upon the concept of operations and the resultant cost savings of these improved capabilities will be explained later in this chapter and in chapter 4.

Table 3-2. Performance Comparison With a 9,800 Foot Critical Field Length

Aircraft	Gross Weight	Best Range Mileage	Maximum Endurance Time
EC-135C (Current)	270,000 lbs.	5,440 NAM	12.8 hrs.
EC-135C (Modified)	295,000 lbs.	6,485 NAM	14.7 hrs.
RC-135 (Current)	270,000 lbs.	4,094 NAM	9.7 hrs.
RC-135 (Modified)	295,000 lbs.	4,927 NAM	11.0 hrs.

NOTE: Apply the same factors as in table 3-1.

SOURCE: The same as for table 3-1.

One final comment on the modified aircraft maximum takeoff gross weight of 320,000 pounds: the limit of only 10,500 feet of runway available under peacetime criteria at Offutt AFB results in the possible use of such weight only during winter months. A Category II condition where the critical field length equals the runway available exists when the temperature is 37°F. A Category I condition where critical field length is reduced to 10,000 feet occurs with a temperature of 14°F. (9:1A2-5,1A2-9,1A3-42) Since these aircraft base their takeoff capabilities almost entirely on peacetime criteria, the full potential of the 320,000 pound

aircraft maximum takeoff gross weight could only be used at the lower temperatures.

OPERATING ALTITUDES

In addition to the improved takeoff performance, the new engines provide an increased thrust-to-weight ratio that allows the aircraft to operate at higher altitudes. This improved capability would impact upon RC-135 deployments and operational missions, EC-135C daily and EWO missions, and the refueling altitude regimes of both aircraft. Comparative figures for these phases of flight are reflected in table 3-3.

EC-135C

The EC-135C aircraft can realize operational advantages from an altitude increase both on a daily basis and during EWO conditions. Changing the daily operations from FL 260 to FL 330 with the new engines would more closely correlate the actual aircraft altitude with the recommended best endurance altitude through the entire flight. It would also increase the range of line-of-sight communication equipment. This connectivity range increase could result in expanded borders for the operating areas, allowing a more dispersed flight path. During EWO conditions the current altitude could also be raised by 5-7,000 feet. This would not only extend the range of the air-to-ground link, it would also extend the air-to-air link with other airborne elements of the PACCS network. While operating at the higher altitudes with the CFM-56 engines, the performance of the aircraft and the mission would be improved.

RC-135

For the RC-135 fleet the higher altitudes during deployments and operational missions would have two potential benefits for sensor equipment operation. The first advantage would be a reduction of the continuous and somewhat insidious problem of equipment overheat. Considering a 300,000 pound gross weight aircraft, the best range altitude would climb from 28,000 feet where the standard day temperature is -40°F, to 32,000 feet where the standard day temperature is -55°F. (8:1A1-5) The second benefit of increased altitude is expanded sensor coverage. With the potential for higher data collection routes and orbits, the line-of-sight sensors would be able to "see" further, thus allowing a greater standoff capability from collection sources. (Depending upon the operating area, this enhanced capability could be offset by increased co-channel interference at higher altitudes.) These two benefits are not readily measurable or quantifiable, but they would have a positive impact upon mission accomplishment.

Table 3-3. Current and Modified Aircraft Performance Comparisons

		Current/Modified Capabilities		
		320,000 lbs.	300,000 lbs.	250,000 lbs.
Max Refueling Altitude		28,000'/31,000'	30,000'/32,000'	33,500'/36,000'
Max Endurance Altitude		-----*/31,600'	25,000'/32,000'	28,400'/33,000'
Endurance Time	EC-135C	-----/17.8 hrs.	16.0 hrs./16.3 hrs.	11.9 hrs./11.8 hrs.
	RC-135	-----/14.2 hrs.	12.7 hrs./12.6 hrs.	8.8 hrs./8.5 hrs.
Best Range Altitude		-----/30,900'	28,000'/32,100'	32,600'/35,400'
Range Mileage	EC-135C	-----/7,539 NAM	6,631 NAM/6,848 NAM	4,957 NAM/4,898 NAM
	RC-135	-----/5,905 NAM	5,220 NAM/5,258 NAM	3,610 NAM/3,435 NAM

NOTES: *Data not charted for weights above 300,000 pounds.
ICAO standard day.
Performance degrade as in table 3-1.
Fuel burned at altitude until tanks are empty.

SOURCES: C-135B Performance Data, pp. 1A5-12 and 1A6-9; EC-135C Performance Data, pp. 1A5-10 and 1A6-9; KC-135R Performance Data, pp. 1A5-17, 1A5-18, and 1A6-8; and "Performance Data Corrections."

Refueling Operations

A higher refueling altitude would benefit both aircraft. For the EC-135C aircraft, power response is not a problem during routine peacetime ABNCP refuelings since they are normally conducted at FL 270 with only token onloads. Power response during EWO conditions does become critical as evidenced during Global Shield exercises: refueling an aircraft to the maximum inflight gross weight of 300,000 pounds at a flight level that exceeds the maximum recommended altitude puts the aircraft severely behind the power curve. The re-engined aircraft would be in the realm of positive power response at that altitude at a weight of 300,000 pounds, and would still have the positive response if refueling to an inflight gross weight of 320,000 pounds. The RC-135 aircraft would realize a similar refueling advantage. The RCs would be able to refuel at an altitude more commensurate with the deployment flight levels. This would preclude the need for any descents to accommodate refueling, yet still keep the aircraft in a positive regime of flight control and engine response. For both the EC and the RC aircraft, greater thrust and resultant higher refueling altitudes would allow the airplanes to conduct receiver refueling operations at altitudes more compatible with those used during other mission phases.

LANDING

The retrofit package does not significantly change the landing ground roll, but it does change the aircraft diversion options at landing weights. The stopping distance for aircraft at the maximum landing gross weight of 200,000 pounds is approximately 5,500 feet for current and modified configurations as depicted in table 3-4. Reduced diversion options that result from re-engining become apparent from the decreased range and endurance capabilities. This limitation is caused by the empty operating weight of the aircraft approaching the 200,000 pound maximum landing gross weight and reducing the available fuel reserves. The situation becomes most critical when a diversion must be made after attempting a landing. Although the retrofit does not appreciably affect the actual landing characteristics of the aircraft, the reduced endurance time and diversion range are related factors that will affect flight operations.

Table 3-4. Performance at Landing Maximum Gross Weight

Aircraft	Ground Roll	Best Range Mileage	Maximum Endurance Time
EC-135C (Current)	5,705'	2,911 NAM	7.2 hrs.
EC-135C (Modified)	5,150'	2,549 NAM	6.2 hrs.
RC-135 (Current)	5,700'	1,679 NAM	4.0 hrs.
RC-135 (Modified)	5,150'	1,237 NAM	3.1 hrs.

NOTES: Landing data for 60°F, 50° flaps, 80% delayed braking, and no other corrections.
Performance degrade as in table 3-1.
Fuel burned at altitude until tanks are empty.

SOURCES: C-135B Performance Data, pp. 1A5-10,1A6-9,1A8-32, and 1A8-33; EC-135C Performance Data, pp. 1A5-10,1A6-9,1A9-15, and 1A9-21; KC-135R Performance Data, pp. 1A5-17,1A5-18,1A6-8, 1A9-30, and 1A9-31; and "Performance Data Corrections."

SUMMARY

This chapter reviewed the changes that would occur to the takeoff, cruise, and landing phases of flight resulting from a retrofit of the CFM-56 package. During takeoff, the increased thrust could either provide a greater margin of performance safety or carry additional fuel or equipment. The aircraft would be able to climb to higher cruise altitudes that could increase the coverage of line-of-sight ground equipment and the connectivity of air-to-air links. While refueling, the engines would provide the power to refuel to greater inflight gross weights, refuel at a higher altitude, or both. Finally, during landing there would be little change to aircraft performance, but there would be a reduction in diversion alternatives due to d[illegible]eased fuel reserves at landing weights. While flying the same mission, aircraft performance would generally be improved as a result of increased thrust and greater fuel efficiency.

Chapter Four

FUEL COST SAVINGS

As suggested by the performance data in the previous chapter, one important feature of this re-engining proposal is the fuel economy that could eventually pay for the cost of the retrofit. Several airlines have converted their aircraft to CFM-56 variants to improve takeoff performance, increase range, and reduce operating costs. The Air Force may not be able to capitalize upon such economies as quickly, but a 25 year life cycle costing comparison (as specified in US Air Force Cost and Planning Factors, AF Regulation 173-13) indicates the potential savings. While cost is not the only factor to consider, it is the one most easily quantified for a study of this nature. The following sections of this chapter present the cost savings for each aircraft.

EC-135C FUEL SAVINGS

The EC-135Cs fly a variety of mission profiles. On a daily basis, the aircraft are airborne as SAC's Airborne Command Post, using three airplanes per day, each flying an average mission of 8 hours and 20 minutes. There are also PACCS exercises that may fly as many as two additional airplanes. Training missions are normally flown each day for initial and recurring aircrew proficiency. As a result of these activities both at Ellsworth AFB and Offutt AFB, the average fuel consumed by SAC's EC-135C fleet in one month during fiscal year 1984 was 1.58 million gallons of JP-4. For the entire fiscal year the fuel consumed was 19 million gallons. At a price of $1.00 per gallon of JP-4, the total fuel cost for FY 84 was $19 million. (11:356; 14:1T)

Computations for projected fuel savings can be drawn from the actual fuel savings realized by commercial airlines. Several commercial carriers have converted their DC-8s from JT3D engines (the commercial equivalent of the military TF33-P-9 engines) to CFM-56 engines. The data base of the DC-8s and the -135s should correlate closely since both are 4-engine aircraft with very similar design and performance characteristics. After approximately one year of service, the DC-8 Super 70 series with CFM-56 engines had a 17-22 percent fuel savings over the standard DC-8 aircraft. (5:51) The fuel savings factors of 17, 20, and 22 percent of current EC-135C fuel consumption are presented in table 4-1. For this presentation the 20 percent factor will be used as the average savings to conservatively base further calculations.

PRECEDING PAGE BLANK-NOT FILMED

Table 4-1. Modified EC-135C Fuel Consumption/Savings Comparisons

		Consumption/Savings for Modified Aircraft		
	EC-135C (FY 84)	Savings Factor 17%	20%	22%
Monthly Consumption	1.586*	1.316/.27	1.269/.317	1.237/.349
Annual Consumption	19.035	15.799/3.236	15.228/3.807	14.847/4.188

NOTE: *Figures expressed in millions, either as gallons or dollars since JP-4 cost $1/gallon in FY 84.

SOURCES: U.S. Department of the Air Force. Avfuel Usage/Flying-Hour Performance Report, Wing Base Summary. Denver: AF Accounting and Finance Center, 22 December 1984, p. 356; U.S. Department of the Air Force. Wing/Base MOS Summary-Avfuel Usage/Flying Hour Report. Offutt AFB, NE: 3902 Air Base Wing, 14 November 1984, pp. 10 and 11; and Ropelewski, Robert R. "Reengined DC-8 Transports Achieve Fuel Savings, High Performance." Aviation Week & Space Technology (22 August 1983), p. 51.

The cost recovery may be computed based upon the 20 percent savings factor and the CFM-56 conversion package cost of $16 million per aircraft. (20:--) With a fleet of 12 EC-135Cs the total retrofit would run $192 million. Using an annual cost savings potential of $3.807 million for FY 84 when the price of JP-4 was $1.00 per gallon, the annual and cumulative dollar savings adjusted for inflation are presented in table 4-2. Projecting the conversion out to the expected 25 year life cycle nets a savings of $153.8 million. If the same methodology and inflation factors are continued, complete system payback would occur in an additional four years with a projected savings of $194.1 million at that time. The conclusion from this data is that the proposal has a fuel savings potential that would eventually pay back the full cost of the retrofit package, but would be only 80 percent cost effective at the 25 year life cycle point.

Table 4-2. Modified EC-135C Cumulative Cost Savings

Year	FY 84 Savings		Inflation Factor		Annual Savings	Cumulative Savings
1986	$3.807	x	1.010	=	$3.845	$3.845
1987	3.807	x	1.042	=	3.967	7.812
1988	3.807	x	1.086	=	4.134	11.946
1989	3.807	x	1.126	=	4.287	16.233
1990	3.807	x	1.168	=	4.447	20.680
1991	3.807	x	1.211	=	4.610	25.290
1992	3.807	x	1.256	=	4.782	30.072
1993	3.807	x	1.302*	=	4.957	35.029
1994	3.807	x	1.351	=	5.143	40.172
1995	3.807	x	1.401	=	5.334	45.506
1996	3.807	x	1.452	=	5.528	51.034
1997	3.807	x	1.506	=	5.733	56.767
1998	3.807	x	1.562	=	5.947	62.714
1999	3.807	x	1.620	=	6.167	68.881
2000	3.807	x	1.680	=	6.396	75.277
2001	3.807	x	1.742	=	6.632	81.909
2002	3.807	x	1.806	=	6.875	88.784
2003	3.807	x	1.873	=	7.131	95.915
2004	3.807	x	1.942	=	7.393	103.308
2005	3.807	x	2.014	=	7.667	110.975
2006	3.807	x	2.089	=	7.953	118.928
2007	3.807	x	2.166	=	8.246	127.174
2008	3.807	x	2.246	=	8.551	135.725
2009	3.807	x	2.329	=	8.867	144.592
2010	3.807	x	2.415	=	9.194	153.786
2011	3.807	x	2.505	=	9.537	163.323
2012	3.807	x	2.597	=	9.887	173.210
2013	3.807	x	2.693	=	10.252	183.462
2014	3.807	x	2.793	=	10.633	194.095

NOTES: *Inflation factors not provided in AFR 173-13 beyond 1992. A constant fuel inflation factor of 3.7% was used thereafter since it was the average yearly factor for 1988-92 in AFR 173-13.
Dollars expressed in millions.

SOURCE: U.S. Department of the Air Force. US Air Force Cost and Planning Factors. AF Regulation 173-13. Washington, DC: HQ USAF/ACMC, 1 February 1984, p. 93.

RC-135 FUEL SAVINGS

Due to the nature of its operational missions, the RC-135 fleet faces the added expense of two factors that were not involved with the EC-135Cs. The first factor is the distance required to reach the FOLs. Additional fuel is used during aircraft deployments and redeployments between Offutt AFB and the FOLs. The second factor is a result of the length of the RC-135 operational missions. Most of the missions require one or two inflight refuelings. The savings potential includes not only the reduced fuel consumption, but also the cost benefit of fewer tanker support sorties. Each of these features will be addressed individually, then combined for total savings analysis.

Looking at the fuel economy from the standpoint of fuel burned by the RC-135 fleet, the savings factors and their results are presented in table 4-3. Again, the 20 percent factor is used for this analysis. Based upon a $33 million expenditure for fuel in FY 84 (11:268-271,480,481,483,519,520,539-541,543), the annual cost savings would amount to $6.6 million in 1984 dollars.

Table 4-3. Modified RC-135 Fuel Consumption/Savings Comparisons

	RC-135 (FY 84)	Consumption/Savings for Modified Aircraft — Savings Factor 17%	20%	22%
Monthly Consumption	2.752	2.285/.467	2.202/.550	2.147/.605
Annual Consumption	33.030	27.415/5.615	26.424/6.606	25.763/7.267

NOTE: *Figures expressed in millions, either as gallons or dollars since JP-4 cost $1/gallon in FY 84.

SOURCES: Avfuel Usage/Flying-Hour Wing Base Summary, pp. 268-271,480,481,483,519,520,539-541, and 543; and Ropelewski. "Reengined DC-8 Fuel Savings," p. 51.

The second and more substantial savings factor is that achieved when re-engined aircraft carry more fuel and use it more efficiently, thereby reducing the number of support tanker sorties. CFM International prepared a report assessing the tanker hours saved with the modified RC-135. Using four different mission profiles, the savings ranged from five to ten tanker hours per refueled operational RC-135 sortie. (15:56-7171-051184 - 56-7176-051184) To compensate for the lack of RC-135 degrade factors in that report, a conservative assessment of a savings of five tanker hours per refueled operational sortie was applied in the following computations. Using a KC-135A per flying hour cost of $2,842 from table 2-2 of AF Regulation 173-13, 860 refueled operational RC-135 sorties in FY 84 (21:--), and five tanker hours per sortie, results in an FY 84 refueling support savings of $12.22 million. ($2,842/hr. x 860 sorties x 5 hrs./sortie = $12.22 million) This dollar savings is augmented by the fact that 4,300 tanker hours can be used to fill other refueling requests.

When the fuel savings and the tanker support savings are combined, the time required to recover the cost of the initial modification can be determined. The cost of converting an RC-135 fleet of 19 aircraft at a price of $16 million per copy would be $304 million. Combining the estimated savings of $6.6 million in fuel consumed and $12.22 million in tanker support results in a total savings potential of $18.82 million per year in FY 84 dollars. A further adjustment to the refueling cost per hour was made due to the conversion of the KC-135As to KC-135Rs. Their increased fuel efficiency reduces the fuel burn rate by 27 percent and reduces the per hour operating cost to $2,289* (3:7; 13:11), reducing the total savings potential to $16.44 million per year in FY 84 dollars. This per hour cost was used in the calculations after 1989 (a year arbitrarily selected by the author). With adjustments for inflation factors, the full system payback could be realized in 14 years as depicted in table 4-4.

---

*This figure was derived by determining the fuel ($2,047) and non-fuel ($795) cost per hour to operate a KC-135A from table 2-2 of AF Regulation 173-13. The fuel cost was reduced by 27 percent to $1,494 and added back to the non-fuel cost for a total FY 1984 per hour operating cost of $2,289. The total cost was computed as explained in the text above.

Table 4-4. Modified RC-135 Cumulative Cost Savings

Year	FY 84 Savings		Inflation Factor		Annual Savings	Cumulative Savings
1986	$18.82	x	1.010	=	$19.008	$19.008
1987	18.82	x	1.042	=	19.610	38.618
1988	18.82	x	1.086	=	20.439	59.057
1989	18.82	x	1.126	=	21.191	80.248
1990	16.44*	x	1.168	=	19.202	99.450
1991	16.44	x	1.211	=	19.909	119.359
1992	16.44	x	1.256	=	20.649	140.008
1993	16.44	x	1.302	=	21.405	161.413
1994	16.44	x	1.351	=	22.210	183.623
1995	16.44	x	1.401	=	23.032	206.655
1996	16.44	x	1.452	=	23.871	230.526
1997	16.44	x	1.506	=	24.759	255.285
1998	16.44	x	1.562	=	25.679	280.964
1999	16.44	x	1.620	=	26.633	307.597

NOTES: *Tanker support dollar cost reduced as a result of lower per hour fuel costs by converting KC-135As to KC-135Rs.
Dollars expressed in millions.
Inflation factors computed as explained in table 4-2.

SOURCE: Air Force Planning Factors, AF Regulation 173-13, p. 93.

SUMMARY

Retrofitting both the EC-135C and the RC-135 aircraft with the CFM-56 engine package could achieve a cost savings sufficient to defray the cost of initial modification. The 12 EC-135C aircraft could be modified at a total cost of $192 million. Using an annual fuel savings potential of $3.8 million the program would be paid back 80 percent at the 25 year life cycle point and would be fully paid back at the 29 year point. The 19 RC-135 aircraft could be modified at a total cost of $304 million. Using a combined fuel and support tanker savings potential of $18.82 million per year, the program would be fully paid back at the 14 year point. Therefore, when the aircraft are considered individually, the RC-135s yield a greater return on the investment dollar due to the greater flying hour tasking compared to the EC-135Cs, and the support tanker costs. However, when the cost savings of all 31 aircraft are combined and the cumulative cost factoring is computed, total system payback is accomplished in 18 years, 7 years below the life cycle costing 25 year criteria.

Chapter Five

OTHER FACTORS

While the fuel consumption rates of the last chapter lend themselves to comparative numerical analysis, there are several other advantages of using the CFM-56 retrofit package that should be considered but are not as easily quantified. These advantages become evident when the focus on the impact of the package is expanded from the changes to the aircraft itself to the advantages of system acquisition, consolidated logistical support, and operational flexibility. These factors become significant when considering the long-range impact on aircraft warfighting readiness and sustainability beyond the year 2000. Several of these factors are specifically addressed in this chapter.

POTENTIAL SAVINGS: ACQUISITION AND REUSE

The acquisition process offers several opportunities to realize a cost savings by using the CFM-56 retrofit package on EC-135Cs and RC-135s. First, additional R&D funding would be required to adapt some of the subsystems to the ECs and RCs, but that cost would be a fraction of the R&D costs of initiating an entirely new retrofit program. Also, the per unit cost of the R&D for the KC-135R could be further amortized over the additional 31 aircraft. Second, there would be the economy of scale of converting all of the aircraft with one modification program. (1:75) (The per unit cost of converting 631 airplanes under program A would be less than the cost of converting 600 airplanes under program A and 31 airplanes under program B.) A third factor is timing: the sooner the modification is begun, the sooner the fuel savings will begin to "pay back" the system and provide a return on the investment dollar. In addition, inflation has historically been the single greatest cause of increase in the unit cost of acquisition programs (1:87) and will most likely have an adverse impact upon any delays in initiating this program. Finally, consideration should be given to modifying the ECs and RCs concurrently with the KC-135As and accelerating the program by increasing the monthly delivery rate since "speeding up the delivery rate generally reduces overall program costs." (1:88) However, this must be considered against the realities of the normal cycle of the POM process and its associated delays. The potential of these and other factors that impact upon this particular acquisition proposal would best be determined by further analysis by the Air Force Systems Command.

The per aircraft conversion cost of $16 million may be partially offset by salvaging the parts of the TF33-P-9 engines for use in other aircraft. While the complete TF33-P-9 engine is only used on -135 aircraft, parts from it can be used as spares for other engines. For example, the core of the engine (primarily compressor and turbine blades) is about 50 percent interchangeable with the JT-3D-3B engines used on the KC-135E aircraft. (23:--) There are several other aircraft that use derivatives of the Pratt and Whitney TF-33 core design whose parts compatibility with the TF33-P-9 would have to be assessed. These include the B-52H (TF33-P-3), the E-3 (TF33-PW-100/100A), the C-135B (TF33-P-5), the C-137 (JT3D-3), and the C-141B (TF33-P-7). (12:21; 6:163-165) The possibility for such cost recovery exists, however that recovery would be realized through several major commands and its full potential would best be determined from additional analysis by the Air Force Logistics Command.

At the current rate of expansion of the functions, technology, and concept of operations of both strategic reconnaissance and strategic C^3, it is probable that in the future the -135 airframe will not be able to carry the payload nor operate out of the diversity of runway environments required. Presently plans are being proposed to use a STOL aircraft with much improved performance capability to replace SAC's current reconnaissance and C^3 fleet. Programs for such conversion are projected to occur during the mid-1990s time frame. (23:--) The CFM-56 engine retrofit is designed to supplement that transition rather than replace it. When the new aircraft are commissioned, the current airplanes would have several thousand hours of service life left and could be converted to KC-135Rs to help meet the increasing demands upon the air refueling assets. At that time, only minor internal changes would be necessary with the ECs and RCs. The RCs would also require the addition of a refueling boom. With the potential for conversion to KC-135Rs to further augment the tanker fleet, the utility of these aircraft would extend beyond the interim modification period.

FORWARD OPERATING LOCATIONS/DISPERSAL

In addition to increased performance and increased fuel savings, there is also the opportunity for logistical savings by eliminating the duplicate parts inventories at FOLs. (19:--) Presently, at three of the four RC-135 FOLs there are collocated KC-135A aircraft with J57-P-59W engines that cannot be interchanged with the TF33-P-9 engines of the RC-135 fleet. As a result, spare parts for each engine must be stocked. Modifying the KC-135A and RC-135 aircraft with the same package would standardize the fleet with nearly identical basic airframes. With this increased interchangeability, more parts from one aircraft could be removed during wartime to support mission requirements of the other aircraft. Savings will be realized through the

economy of commonality and consolidation with a single supply system better able to absorb the impact of a series of subcomponent malfunctions.

During peacetime weather diversion or EWO dispersal there are two features of the retrofit package that could increase the number of recovery alternatives. First, commonality between the EC-135Cs, the RC-135s, and the KC-135Rs would result in increased support capabilities at all bases with tanker operations. While this is not the primary consideration during diversions or dispersals, it would mean that the EC and RC aircraft would have a greater number of bases throughout the world where they could recover and obtain maintenance support for the basic airframe. Second, with the dual APU system and the improved self-sustaining capability it provides over the current configurations, the aircraft would have a greater potential for operations from austere or bare-base environments. The increased number of recovery airfields that could be used as a result of these features would enhance planning flexibility.

SUMMARY

Retrofitting the EC-135C and RC-135 aircraft with the CFM-56 re-engine package has several advantages that become apparent when the proposal is viewed from the larger context of system acquisition, logistical support, and operational flexibility. In particular, by "piggybacking" on the KC-135A retrofit program, the modification cost per unit may be reduced for the KCs as well as the ECs and RCs. By salvaging the parts of the TF-33 engines and converting the aircraft to tankers should they be replaced in their current missions, the net modification cost would be reduced while the utility of the aircraft would be increased. The commonality of parts of the three basic airframes (EC, KC, and RC) would result in greater logistical efficiency through consolidation, and greater flexibility for operational planners.

Chapter Six

SUMMARY

CONCLUSIONS

There are benefits of retrofitting SAC's EC-135C and RC-135 aircraft with the CFM-56 engine that would affect performance, cost, and logistical support. Increased performance from this modification would result in improved takeoff capabilities, better receiver refueling power response, and higher operational altitudes that would expand the coverage of line-of-sight equipment. The potential for operational equipment expansion, also resulting from the increased performance, would be negated by the fact that the RCs are currently and the ECs will soon be "cubed out." Major system additions in the future would have to be exchanged with existing components. The improved efficiency of the engines would provide a payback on the investment dollar by reducing the amount of fuel burned. Since the RCs require an aerial refueling on most of their sorties (while the ECs do not), they would also realize a savings by reducing the number of support tanker hours. Finally, logistical economies could be realized by salvaging the TF33-P-9 engines, increasing the parts commonality between the KC-135R fleet and the EC and RC aircraft, and converting the aircraft to tankers when they are replaced by a follow-on airframe. These benefits cover a broad range of factors associated with weapon system operations.

The disadvantages of the CFM-56 re-engining package affect landing diversion options and cost. Landing diversion options would be reduced as the empty operating weight of the aircraft approaches the maximum landing gross weight of 200,000 pounds, thus limiting the amount of fuel available for diversions. The R&D associated with modifications such as those to the generators and the APUs would adversely affect the program in that the costs of such R&D must be amortized solely by the 31 aircraft of the EC and RC fleets. These disadvantages must be weighed against the benefits.

PRECEDING PAGE BLANK-NOT FILMED

RECOMMENDATIONS

Before a program to retrofit the EC-135Cs and the RC-135s is initiated, several additional studies or analyses should be conducted to determine equipment compatibility, modifications that would be necessary, and the R&D or additional costs that would be incurred by the modifications. These costs could significantly increase the acquisition price per aircraft. The studies that have been suggested throughout this paper are summarized below.

1. Determine the ability of the CFM-56 engines to accommodate the 120 KVA generators, and the ability of the IDG control center to manage the 120 KVA output.

2. Determine whether or not the normal landing maximum gross weight could be increased.

3. Determine the trade-off between the cost savings of retaining the current Mark II brake system versus the logistical advantages of commonality throughout the fleet with the Mark III brake system.

4. Identify an APU that would meet both the space limitations and the power output specifications.

5. Determine the economies of acquisition associated with this particular program.

6. Determine any cost savings that may be realized by salvaging the TF33-P-9 engines or their parts.

The system net cost increase or decrease based upon the findings of these studies could significantly change the payback period of the modification and the cost effectiveness of the proposal. If the payback period for the 31 aircraft remains less than 25 years, the increased performance, logistical commonality with the KC-135R, and potential for continued use as a tanker after a follow-on airframe is procured are factors that put this program in strong contention for implementation.

BIBLIOGRAPHY

A. REFERENCES CITED

Books

1. Beckstead, Robert W., Hitch, Charles J., and McKean, Roland N. Defense Economic Issues. Washington, D.C.: National Defense University, 1982.

2. Taylor, John W. R. (ed.). Jane's All the World's Aircraft 1983-1984. London: Jane's Publishing Co., Ltd., 1984.

Articles and Periodicals

3. Kotti, George H. "Here Come the R's...." Combat Crew, June 1984, pp. 4-7.

4. Ropelewski, Robert R. "CFM56s Boost KC-135R Performance." Aviation Week & Space Technology, Vol 118, No 18 (2 May 1983), pp. 42-46.

5. -----. "Reengined DC-8 Transports Achieve Fuel Savings, High Performance." Aviation Week & Space Technology, Vol 119, No 8 (22 August 1983), pp.48-54.

6. Young, Susan H. H., and Taylor, John W. R. (eds.). "Gallery of USAF Weapons." Air Force Magazine, Vol 67, No 5 (May 1984), pp.163 and 165.

Official Documents

7. C-135B Flight Manual, Appendix I, Performance Data. Published under authority of the Secretary of the Air Force, June 1966.

8. EC-135C Flight Manual, Appendix I, Performance Data. Published under authority of the Secretary of the Air Force, February 1966.

9. KC-135R Flight Manual, Appendix I, Performance Data. Published under authority of the Secretary of the Air Force, March 1984.

CONTINUED

10. U.S. Air Weather Service. Base Weather Climatology. Offutt AFB, NE: Det 1, 3rd Weather Wing, 21 June 1979.

11. U.S. Department of the Air Force. Avfuel Usage/Flying-Hour Performance Report, Wing Base Summary. Denver: AF Accounting and Finance Center, 22 December 1984.

12. U.S. Department of the Air Force. SAC Facts Book. Offutt AFB, NE: Strategic Air Command, 1 July 1984.

13. U.S. Department of the Air Force. US Air Force Cost and Planning Factors. AF Regulation 173-13. Washington, D.C.: U.S. Government Printing Office, 1 February 1984.

14. U.S. Department of the Air Force. Wing/Base MOS Summary-Avfuel Usage/Flying Hour Report. Offutt AFB, NE: 3902nd Air Base Wing, 14 November 1984.

Unpublished Materials

15. "CFM 56 for Special Purpose C-135's." Briefing prepared by CFM International, May 1984.

16. Kazin, Stephen B. "KC-135/CFM56 Re-Engine, The Best Solution." American Institute of Aeronautics and Astronautics, Inc., 1983.

17. "Performance Data Computations." A performance degrade worksheet used by RC-135 aircrews.

18. "System/Subsystem Summary Report—KC-135 Re-Engine." The Boeing Company, 22 April 1980.

Other Sources

19. Booth, John W. SAC Command Engine Manager, Propulsion Branch, Directorate of Aircraft Maintenance, Headquarters Strategic Air Command, Offutt AFB, NE. Telecom with the author, 9 January 1985.

CONTINUED

20. Kotti, George H., Maj, USAF. KC-135R Acquisition Manager, Tanker Branch, Air Vehicles Division, Directorate of Aeronautical Requirements, Headquarters Strategic Air Command, Offutt AFB, NE. Telecom with the author, 7 December 1984.

21. Phillips, Roy B., Lt Col, USAF. Force Management and C^3 Development Officer, C^3 Force Management Division, Directorate of Force Management and Space Requirements, Headquarters Strategic Air Command, Offutt AFB, NE. Telecom with the author, 14 January 1985.

22. -----. Telecom with the author, 7 February 1985.

23. Unruh, Sheryl, SSgt, USAF. Base Engine Manager, Propulsion Branch, 55th Field Maintenance Squadron, Offutt AFB, NE. Telecom with the author, 29 November 1984.

B. RELATED SOURCES

Articles and Periodicals

"CFM56s Show Dispatch Reliability of 99.8%." Aviation Week & Space Technology, Vol 118, No 18 (2 May 1983), pp. 30 and 31.

Lenorovitz, Jeffrey M. "CFM56 Powerplant Fixes Based on DC-8 Operations." Aviation Week & Space Technology, Vol 118, No 7 (14 February 1983), p. 32.

Scott, William B. "Reengined KC-135 Shows Performance Gains in Test." Aviation Week & Space Technology, Vol 118, No 8 (21 February 1983), p. 53.

Unpublished Material

Spooner, Ben W. Manager, Operations Analysis, Boeing Military Airplane Company, Wichita, KS. "KC-135[R] Ground Clearance and FOD Susceptability [sic]." Letter plus attachments to Steven B. Kazin, Manager, Advanced Military Applications, CFM International, 13 September 1982.

APPENDICES

PRECEDING PAGE BLANK-NOT FILMED

APPENDIX 1

ABBREVIATIONS AND ACRONYMS

ABNCP	Airborne Command Post
AFB	Air Force Base
AFR	Air Force Regulation
APU	Auxiliary Power Unit
C	Centigrade
C^3I	Command, Control, Communications, and Intelligence
CINC	Commander in Chief
CONUS	Continental United States
ECS	Environmental Control System
EFAS	Engine Failure Assist System
EMP	Electromagnetic Pulse
EWO	Emergency War Order
F	Fahrenheit
FL	Flight Level
FOL	Forward Operating Location
FY	Fiscal Year
GE	General Electric
GWEN	Ground Wave Emergency Network
ICAO	International Civil Aviation Organization
IDG	Integrated Drive Generator
KEAS	Knots Equivalent Airspeed
KVA	Kilovoltampere
MILSTAR	Military Strategic and Tactical Relay System
NAM	Nautical Air Miles
NDS	Nuclear Detection System
PA	Pressure Altitude
PACCS	Post Attack Command and Control System
PMC	Power Management Control
POM	Program Objective Memorandum
R&D	Research and Development
RPM	Revolutions per Minute
SAC	Strategic Air Command
SIGINT	Signals Intelligence
SNECMA	Société Nationale d'Etude et de Construction de Moteurs d'Aviation
STOL	Short Takeoff and Landing
TDY	Temporary Duty
TEMS	Turbine Engine Monitoring System
WWABNCP	World Wide Airborne Command Post

APPENDIX 2

SYSTEM CHANGES IN THE KC-135R PACKAGE

The following systems or subsystems are being replaced, modified, or added as part of the CFM-56 engine retrofit package on the KC-135A to convert it to the KC-135R. (18:8,9)

Air Conditioning Control
Airplane Lighting
Anti-Ice Panel
Autopilot System
Auxiliary Power Unit (APU) Quick Start System
Battery Power Panel
Brake and Anti-Skid System
Cabin Pressure Control
Cabin Pressure Indicator
CFM56-2B-1 Engine
Cockpit Instruments and Controls
Control Stand
Electrical Control Panel
Electrical System
Engine Instruments
Engine Start Panel
Fire Detection and Fire Extinguishing Systems
Fire Extinguisher and Overheat Panel
Flight Control Augmentation System
Fuel System
Fuel Temperature Gage
Horizontal Stabilizer
Hydraulic System
IFF Transponder Control
Inlet Cowl Anti-Ice System
Landing Gear
Leading Edge Flaps
Pneumatic System
Rudder PCU Plumbing
Rudder Pedal Coupled Nose-Wheel Steering System

END

DATE
FILMED

8-85

DTIC